Water impoundment by water spreading dike at Williston Branch Experiment Station.

PERENNIAL FORAGE PRODUCTION WITH A WATER SPREADING SYSTEM

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A water spreading system directs water from natural drainage ways and spreads it by means of a dike or a series of dikes across a large area, allowing gradual infiltration of water into the soil profile. Use of water spreading systems has steadily increased in North Dakota. Each year for the last nine years an average of 1,000 acres of land has been converted to use water spreading as a means of water conservation.[1] More than 90 per cent of these systems are located in western North Dakota.

Researchers (2, 6, 11) working in the semi-arid eastern Montana regions have improved native ranges by using water spreading systems. Tadmor et. al. (13) found that alfalfa **(Medicago sativa)** would produce very high yields when water was trapped and made available by a water spreading system.

[1] Peter Balkan, irrigation specialist, U.S. Soil Conservation Service, Bismarck, North Dakota. Personal communication.

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Level bench terraces also are a comparable means of water conservation. Haas and Willis (5) have shown that alfalfa production can be more than doubled by trapping snow and spring run-off water with terraces. These benches store enough water in the soil to allow larger second cuttings and possibly third cuttings.

The object of this study was to determine the value of a water spreading system for alfalfa and tame grass production in western North Dakota with and without nitrogen fertilization.

Procedure

In late 1961, a 700-foot dike was constructed across a natural waterway on the Williston Branch

Experiment Station. The dike had a maximum height of three feet and side slopes of 4 to 1 on the upstream side. The watershed contributing to the system was relatively small, about 140 acres. A 12-inch culvert was placed in the dike to serve as a turnout to control water depth.

On May 23, 1962, Nordan crested wheatgrass (**Agropyron desertorum** Fisch.), Lincoln and Canadian No. 1 smooth bromegrass (**Bromus inermis** Leysa.), three varieties of inoculated alfalfa (Vernal, Teton and Ladak) and two alfalfa (inoculated)-grass mixtures (Canadian No. 1 + Vernal and Nordan + Vernal) were sown on summerfallow. Grasses were sown at 12 lb/a, alfalfa at 8 lb/a and the mixtures at 4 and 6 lb/a of grass and alfalfa, respectively. Prior to seeding, the plot site was fertilized with 54 lb/a of nitrogen, 28 lb/a of P_2O_5 and no potash. No soil test was taken.

Duplicate seedings were made; one upstream of the dike (hereafter referred to as the wet side) and one downstream of the dike (hereafter referred to as the dry side). The seedings were replicated three times. Yields reported are the mean of the three replications. Good stands were established on both sides. A fertilizer variable of 50 pounds per acre of nitrogen (ammonium nitrate) applied annually in the fall also was included. Soil type at the plot site is a Grail silty clay with a gravelly substratum.

Precipitation received during the four years of the study is shown in Table 1. In 1963, no appreciable spring run-off occurred, but run-off from early July rains was entrapped by the spreader dike. In 1964 and 1966, early spring run-off flooded the wet side of the dike for about a week. Water depth was about 6 inches. Late May rains in 1965 caused considerable flooding on both the dry and wet sides of the dike.

Table 1. Precipitation Received at the Williston Experiment Station 1963-66.

	Precipitation - Inches					
	Monthly					±
Year	May	June	July	Total	Annual	Normal
1963	2.31	3.07	4.47	9.85	17.06	+3.36
1964	1.08	4.56	2.59	8.23	12.84	−1.99
1965	8.09	1.88	1.81	11.78	19.01	+4.62
1966	1.91	1.06	2.91	5.88	9.87	−4.52

Crop Response to Nitrogen

Fifty-four pounds per acre of nitrogen was applied to the plot sites prior to seeding in 1962. In 1963, only small forage yield responses to nitrogen occurred, perhaps due to residual nitrogen from the 1962 application. For this reason, only 1964-66 data were used to evaluate forage crop response to nitrogen.

Average forage production (1964-66) of crested wheatgrass about doubled from an annual application of 50 pounds N per acre, while the average forage production of the two bromegrass varieties increased about 150 per cent in response to applied nitrogen (Fig. 1). This forage response to nitrogen was about the same whether these grasses were grown on the wet or dry side of the spreader dike. These results correspond with results from other studies (3, 4, 8, 9) that show that proper nitrogen fertilization of tame grasses increases yields considerably, particularly in years of average or above average precipitation (12).

The response of alfalfa varieties and alfalfa-grass mixtures to nitrogen fertilizer was erratic from year to year (Tables 2 and 3). Generally, the alfalfa (average of all three varieties) and alfalfa-grass mixtures (average of two mixtures) grown on the wet side of the dike did not respond to application of nitrogen (Fig. 2). Apparently the alfalfa was able to supply the crops' nitrogen requirements. However, alfalfa and alfalfa-grass mixtures grown on the dry side responded to N fertilization with increases in forage production of 48 and 38 per cent, respectively. Nitrogen fertilizer application to alfalfa is not a recommended practice in North Dakota, but perhaps under the semi-arid conditions of western North Dakota the nitrogen-fixing bacteria in the nodules of alfalfa roots cannot consistently supply all the nitrogen needed by alfalfa or alfalfa-grass mixtures. This observation agrees with those of others who suggest that alfalfa may not fix enough nitrogen for its own maximum growth (1), let alone for an associated grass (7, 9, 10).

Effect of Water Spreading System

The water spreading dike effectively trapped runoff water each year. Figure 3 shows little advantage for growing crested wheatgrass or bromegrass in a water spreading system, since forage production of either was increased only 10 to 15 per cent. Applying nitrogen to either grass increased forage production on the dry side to a level approximately equal to forage production on the wet side. These grasses would not be able to make effective use of runoff water trapped in late June or July that allow second and perhaps third cuttings, since regrowth is slow. This is particularly true for crested wheatgrass because it is an early, cool season grass.

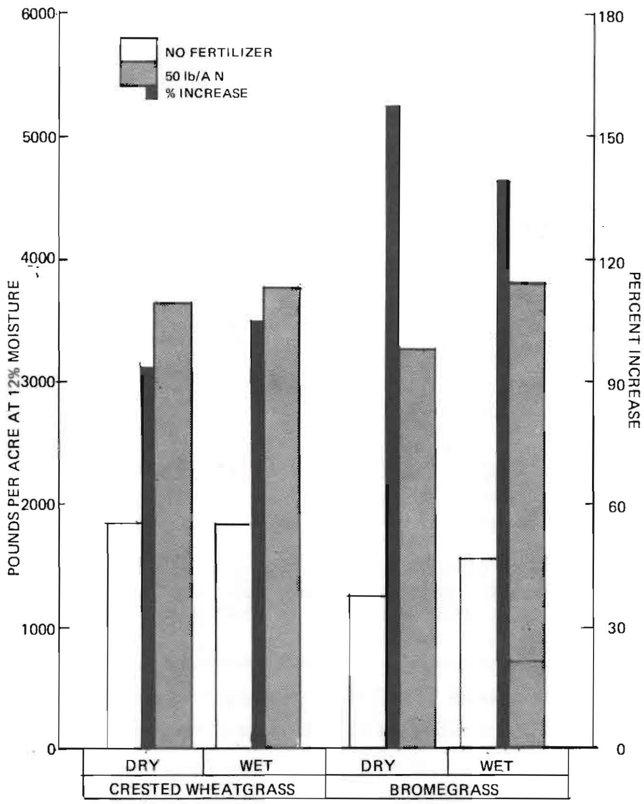

Figure 1. Average Yield Response (1964-66) of Crested Wheatgrass and Bromegrass to Nitrogen Fertilizer-Wet and Dry Side of Spreader Dike.

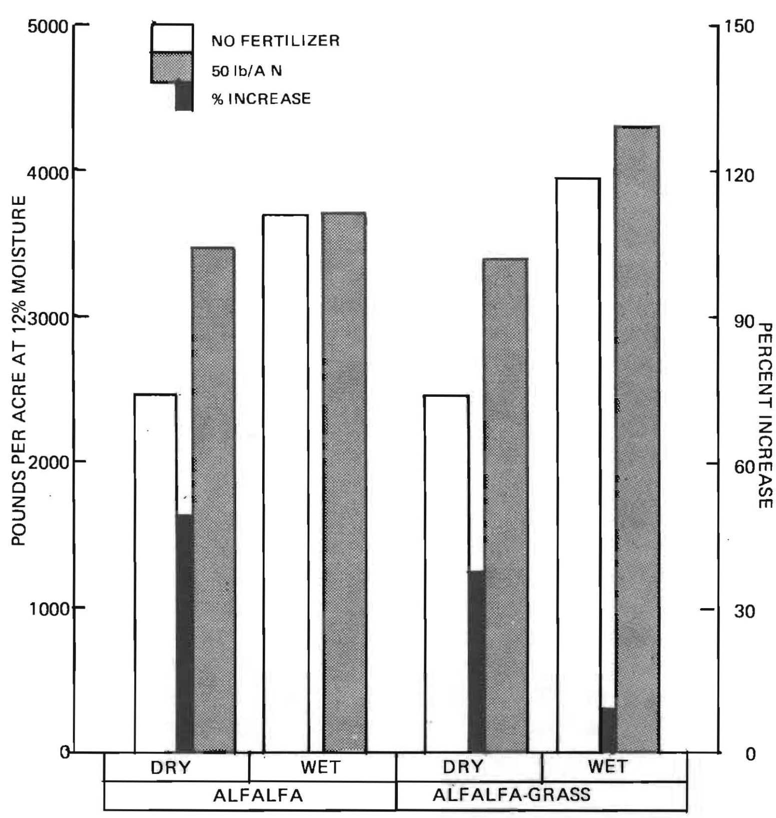

Figure 2. Average Yield Response (1964-66) of Alfalfa and Alfalfa-grass Mixtures to Nitrogen Fertilizer-Wet and Dry Side of Spreader Dike.

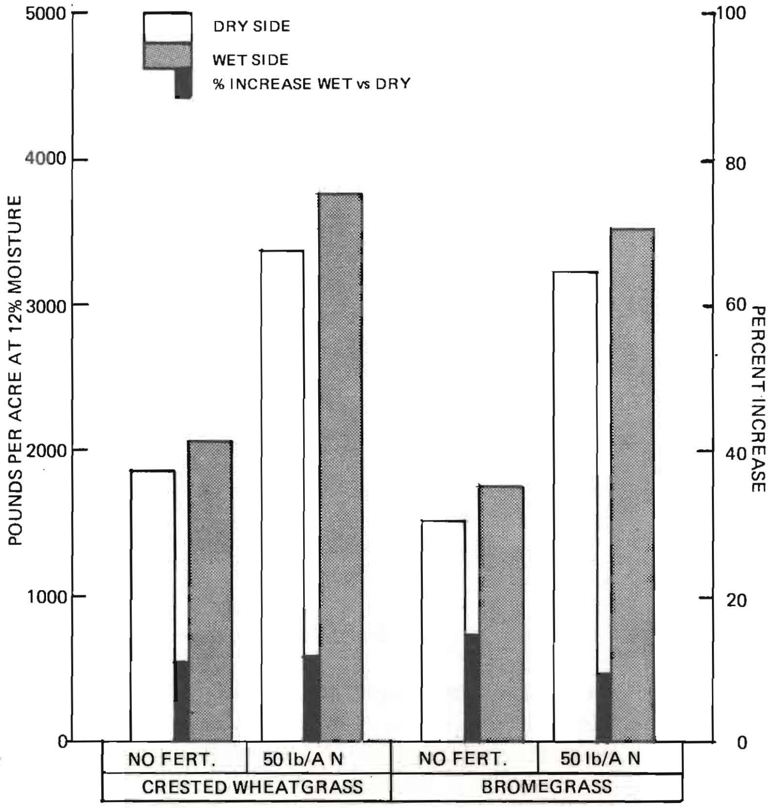

Figure 3. Average Yield Response (1963-66) of Crested Wheatgrass and Bromegrass to a Water Spreading System with and without Nitrogen Fertilizer.

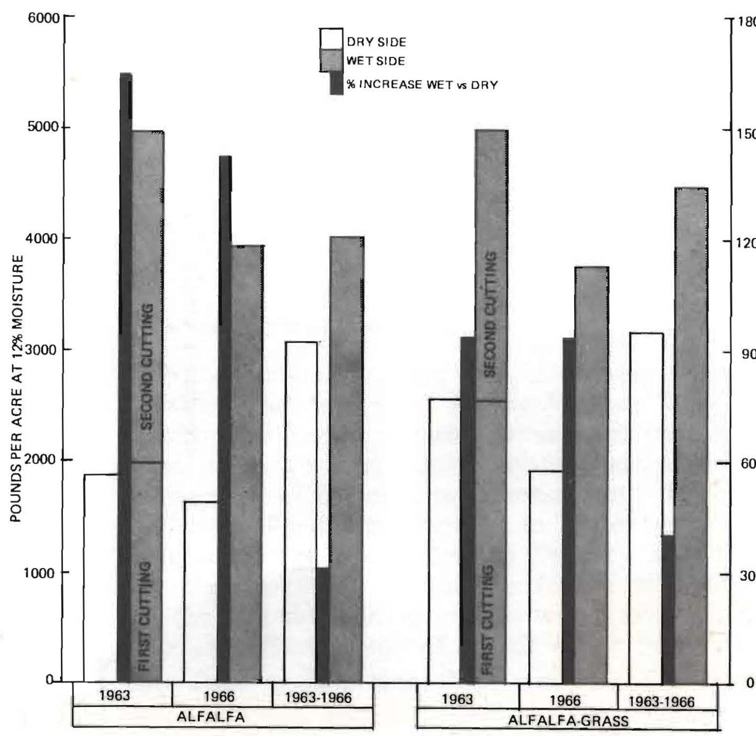

Figure 4. Average Yield Response of Alfalfa and Alfalfa-grass Mixtures to a Water Spreading System When Fertilized with Nitrogen.

Table 2. Forage Yield Data for Eight Entries Grown on the Wet Side of a Water Spreading System, With and Without Nitrogen Fertilizer at Williston, 1963-66.

	Pounds Per Acre at 12% Moisture											
	1963		1964		1965		1966		1963-66		1964-66	
Entry	N_0 [1]	N_1 [1]	N_0	N_1	N_0	N_1	N_0	N_1	N_0	N_1	N_0	N_1
Grasses												
Nordan Crested Wheat	2774	3370@[2]	1713	3814*	2167	3494*	1634	3974@	2072	3665	1838	3761*
Lincoln Brome	2094	3027*	2246	4560*	1659	5227*	1336	3226@	1832	4010*	1747	4338*
Canadian #1 Brome	2246	2274	1620	4380*	1520	2773*	1180	2640@	1642	3012*	1440	3264*
Alfalfa												
Ladak	4987	5393	3527	3386	4119	5460*	3280	2500	3978	4185	3642	3782
Vernal	5279	4946	3560	3566	5100	4846	2726	2614	4167	3994	3795	3675
Teton	4207	4526	3006	2826	4466	5426*	3207	2700	3722	3870	3660	3651
Mixtures												
Canadian #1/Vernal	4507	4627	3306	3780	4286	6033*	3627	3067	3932	4377	3740	4293
Nordan/Vernal	5013	5306	3680	4233	5213	4426	3780	4434	4422	4600	4224	4364
LSD 5%	711.8	711.8	873.3	873.3	671.3	671.3	829.8	829.8	379.4	379.4	423.7	423.7

[1] *N_0 = check, no nitrogen applied; N_1 = 50 lb/A nitrogen fall applied.*
[2] ** and @ indicates significant difference at the 5% and 10% levels, respectively when comparing fertilizer treatments within an entry and an individual year.*

Table 3. Forage Yield Data for Eight Entries Grown on the Dry Side of a Water Spreading System, With and Without Nitrogen Fertilizer at Williston, 1963-66.

	Pounds Per Acre at 12% Moisture											
	1963		1964		1965		1966		1963-66		1964-66	
Entry	N_0	N_1 [1]	N_0	N_1	N_0	N_1	N_0	N_1	N_0	N_1	N_0	N_1
Grasses												
Nordan Crested Wheat	1840	2587*[2]	2014	3867*	2587	4340*	1040	2694	1870	3372*	1880	3634*
Lincoln Brome	2654	3374*	1347	3787*	1860	5140*	760	1880	1656	3544*	1322	3602*
Canadian #1	1807	2620*	1386	3833*	1660	3693*	667	1434	1380	2896*	1238	2987*
Alfalfa												
Ladak	1747	1920	1840	4140*	4187	4926@	1487	1980	2316	3242*	2505	3682*
Vernal	1994	2247	2267	3514@	4227	5674*	1386	1627	2468	3265*	2627	3605*
Teton	1400	1454	1920	3340@	4020	4734@	940	1306	2076	2708*	2293	3127*
Mixtures												
Canadian #1/Vernal	2034	2520	1980	3120@	3693	5786*	987	1454	2174	3220*	2220	3453*
Nordan/Vernal	1394	2620*	2207	2960	4620	4647	1340	2433	2390	3166*	2722	3347@
LSD 5%	457.5	457.5	790.5	790.5	532.5	532.5	528.0	528.0	285.6	285.6	296.6	296.6

[1] *N_0 = check, no nitrogen applied; N_1 = 50 lb/A nitrogen fall applied.*
[2] ** and @ indicates significant difference at the 5% and 10% levels, respectively when comparing fertilizer treatments within an entry and an individual year.*

Figure 4 shows 1963, 1966 and average (1963-66) yield responses of alfalfa and alfalfa-grass mixtures to water spreading system when adequately fertilized with nitrogen. Precipitation received in May, June or July each year (Table 1) influenced crop response to the system. The dike trapped runoff water from early July rains in 1963 and made possible a second cutting. This is the only year in the four years of this study that a second cutting was possible. Without the second cutting, forage production from the dry and wet sides are about equal.

In 1966, very dry weather conditions limited forage production on the dry side, but wet side forage production was very good because early spring runoff supplied sufficient stored soil moisture to increase yields. In both 1963 and 1966, yield increases comparing dry versus wet side with adequate nitrogen fertilization amounted to approximately 150 and 90 per cent for alfalfa and alfalfa-grass mixtures, respectively. These results generally agree with those of Haas and Willis (5). Early June rains in 1964 delayed first cutting harvest. Late May rains flooded both sides of the dike in 1965. No production increases occurred that can be attributed to the water spreading system in 1964 or 1965.

Yield increases of alfalfa and alfalfa-grass mixtures grown without adequate nitrogen fertilization are generally higher in response to the water spreading system than increases for adequately fertilized production (Tables 2 and 3). This is particularly true for alfalfa-grass mixtures. This again indicates that the alfalfa was better able to supply nitrogen for maximum production when the water spreading system apparently increased stored soil moisture.

General observations regarding variety performance are apparent from 1963-66 average yields (Tables 2 and 3). Canadian No. 1 bromegrass generally yields less than Lincoln bromegrass. Production levels of Nordan crested wheatgrass and Lincoln bromegrass are about equal. Teton alfalfa generally yields less than Vernal and Ladak under drier conditions. Average production of Canadian No. 1/Vernal and Nordan/Vernal mixtures were generally about the same. Stands of grass in the mixtures remained at about 50 per cent throughout the study.

Conclusions

Fertilizing crested wheatgrass and bromegrass with 50 lb/a of nitrogen annually more than doubled their forage production. These grasses, if adequately fertilized with nitrogen, generally would show little production advantage when grown in a water spreading system. Alfalfa and alfalfa-grass mixtures responded to nitrogen fertilizer when average or below average precipitation was received. More research is needed to determine if this condition is more than just one isolated case in western North Dakota.

Of the treatments studied, alfalfa and alfalfa-grass mixtures responded best to excess water trapped by the water spreading system. The system should at least double forage production in very dry years or in years when second cuttings are made possible by trapping timely runoff water. A good water spreading system should insure consistent production of alfalfa or alfalfa-grass mixtures in semi-arid western North Dakota.

From the Director . . . (continued from page 2)

ing to energy conservation; in waste disposal and pollution control; and by the addition of an immunologist-serologist in the Veterinary Science Animal Diagnostic Laboratory to assist in providing a greater breadth of competence in this important segment of the Agricultural Experiment Station program.

These efforts will mean personnel additions to the departments of Agricultural Engineering, Animal Science, Bacteriology, Biochemistry, Botany, Plant Pathology, Soils, and Veterinary Science, and two joint appointments with the Cooperative Extension Service. Technicians to assist existing professional personnel will also be provided in Agronomy, Biochemistry, Entomology, and Horticulture and Forestry.

This is the first significant addition to agricultural research capability which has been provided to this Station by state legislative action for several bienniums, and this investment in the future agricultural production capability of our North Dakota farms and ranches will pay handsome dividends.

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